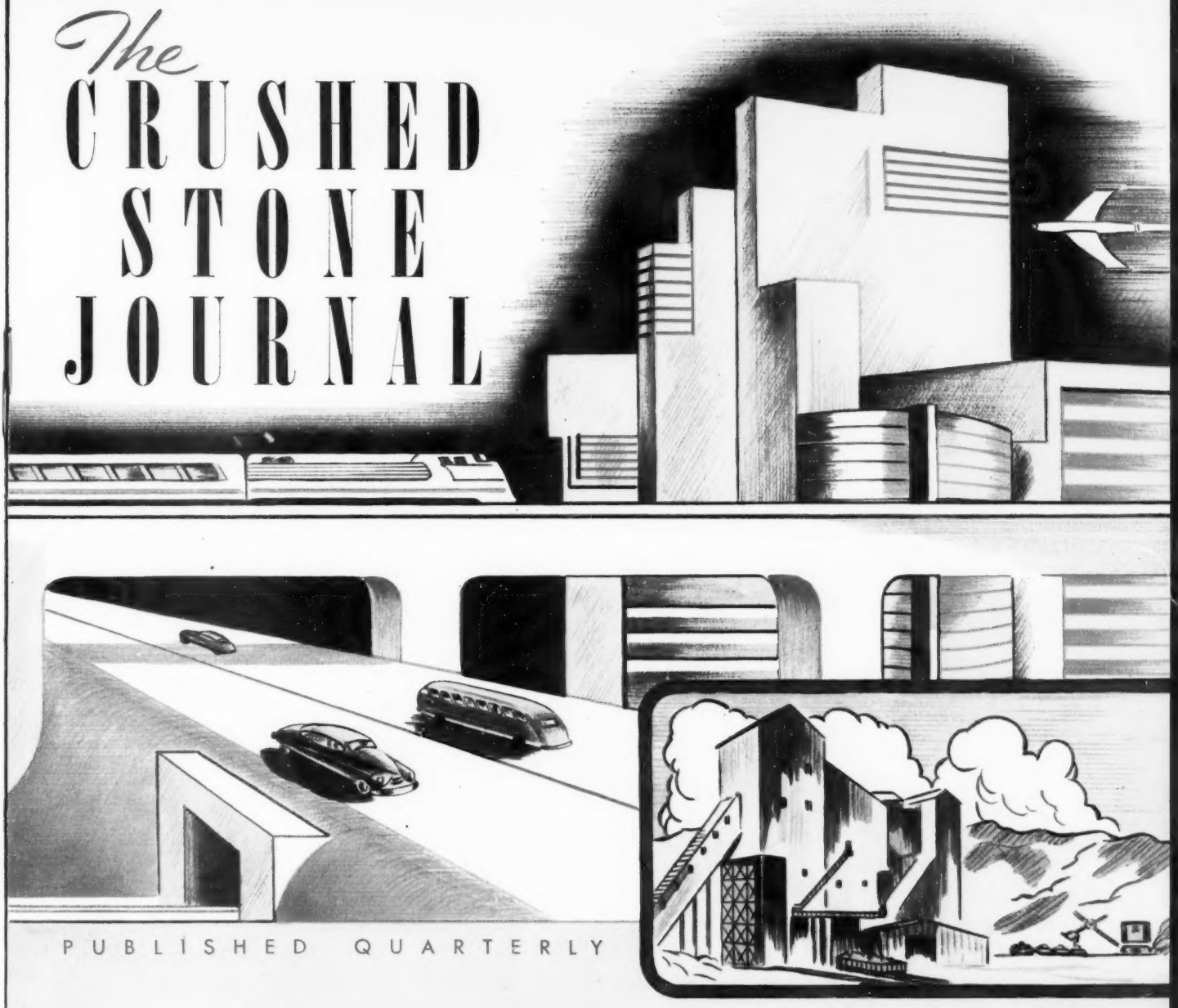
The CRUSHED STONE JOURNAL



PUBLISHED QUARTERLY

In This Issue

December 1953

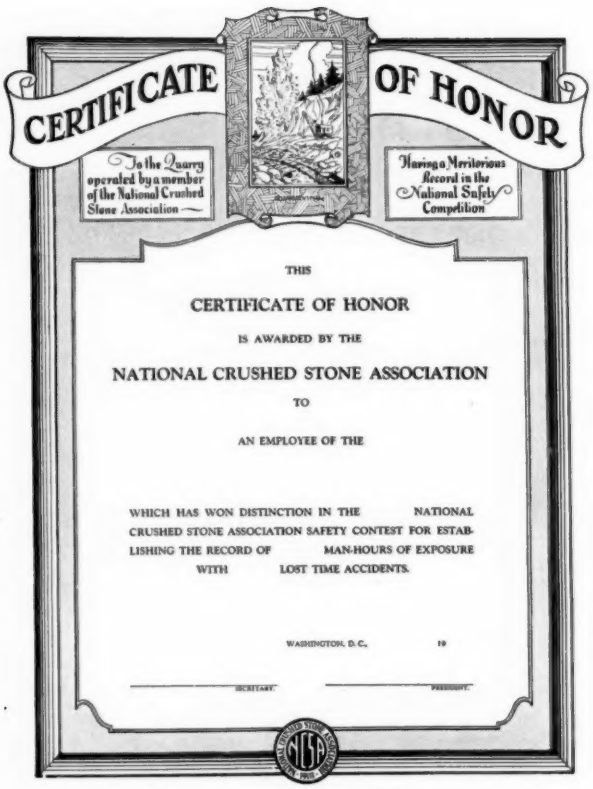
- Quarry Operators to Meet in Chicago February 22-24, 1954
- General Characteristics of Concrete Cracking
- The Importance of Developing a Realistic National Program for Highway Construction
- $575 Million Apportioned for Federal-Aid Highways

OFFICIAL PUBLICATION · NATIONAL CRUSHED STONE ASSOCIATION

Quarry Operators—

HAVE YOU ENTERED THE NCSA SAFETY COMPETITION FOR 1954?

ENROLL NOW


CERTIFICATE OF HONOR
To the Quarry operated by a member of the National Crushed Stone Association
Having a Meritorious Record in the National Safety Competition
THIS
CERTIFICATE OF HONOR
IS AWARDED BY THE
NATIONAL CRUSHED STONE ASSOCIATION
TO
AN EMPLOYEE OF THE
WHICH HAS WON DISTINCTION IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY CONTEST FOR ESTABLISHING THE RECORD OF MAN-HOURS OF EXPOSURE WITH LOST TIME ACCIDENTS.
WASHINGTON, D.C., 19
SECRETARY
PRESIDENT

OBTAIN ENTRY BLANKS FROM:

Accident Analysis Branch
U. S. Bureau of Mines
Washington 25, D. C.

• ● •

THIS Certificate of Honor is presented to each employee of each plant which completes a year with no lost time accidents.

The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

NATIONAL CRUSHED STONE ASSOCIATION

1415 Elliot Place, N. W.
Washington 7, D. C.

OFFICERS

H. C. KRAUSE, President
JAMES SAVAGE, Treasurer
J. R. BOYD, Administrative Director
A. T. GOLDBECK, Engineering Director
J. E. GRAY, Field Engineer

REGIONAL VICE PRESIDENTS

L. J. BOXLEY — A. W. McTHENIA
BRUCE S. CAMPBELL — S. P. MOORE
A. J. CAYIA — WARREN C. ROWE
E. EIKEL — BRUCE G. WOOLPERT

EXECUTIVE COMMITTEE

H. C. KRAUSE, Chairman
J. REID CALLANAN — S. P. MOORE
T. C. COOKE — RUSSELL RAREY
IRWIN F. DEISTER — W. S. WESTON, JR.
WILSON P. FOSS, III — W. F. WISE
OTHO M. GRAVES, Honorary Member

Contents

	Page
Quarry Operators to Meet in Chicago February 22-24, 1954	3
General Characteristics of Concrete Cracking By L. Boyd Mercer, M.C.E.	6
The Importance of Developing a Realistic National Program for Highway Construction By Gen. Eugene Reybold	13
$575 Million Apportioned for Federal-Aid Highways	15

MAKE YOUR HOTEL RESERVATIONS *in Advance*

The Conrad Hilton, Chicago, Ill.

For the
37th Annual Convention
and
Exposition

NATIONAL CRUSHED STONE ASSOCIATION

CONRAD HILTON HOTEL
CHICAGO, ILLINOIS

FEBRUARY
22, 23, and 24, 1954

- With registration expected to exceed all previous records, it is highly important that hotel reservations be made in advance
- Plan, wherever possible, to arrive in Chicago on Sunday, February 21
- To insure preferential handling of requests for room reservations, make use of special NCSA reservation card

Cards may be obtained by writing direct to
NATIONAL CRUSHED STONE ASSOCIATION
1415 ELLIOT PLACE, N. W. • WASHINGTON 7, D. C.

The Outstanding Event of the Year for Crushed Stone Producers

THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol. XXVIII No. 4 PUBLISHED QUARTERLY DECEMBER 1953

Quarry Operators to Meet in Chicago February 22-24, 1954

Demand for Exposition Space Breaks all Previous Records

FOR quarry operators, the outstanding event of the year is the Annual Convention of the National Crushed Stone Association. This is especially true of the even years when the Manufacturers Division Biennial Exposition is held in conjunction with the Annual Convention. Such will be the case in 1954 when the 37th Annual Convention and Exposition will take place at The Conrad Hilton, Chicago, Illinois, February 22, 23, and 24.

Program arrangements for this traditionally important occasion are substantially completed, and give assurance that the more than one thousand delegates in attendance will be repaid many fold for the time and expense involved in making the trip.

The Manufacturers Division Exposition, which will not be held again until 1956, grows in importance and value with the passing of the years. At no other time and under no other circumstances is the quarry operator afforded a similar opportunity to view, under one roof, improvements and developments in machinery and equipment utilized in the production of crushed stone. It should also be remembered that the manufacturers of machinery and equipment will have present at the Convention their technical men for consultation with quarry operators on problems of a specialized nature. A preliminary review of the nature and character of the exhibits which will be on display clearly indicates that the members of our Manufacturers Division are going all out to make this Exposition the most comprehensive and informative since the establishment, many years ago, of this feature of the Annual Meeting.

Two full Convention sessions, the first on Monday afternoon and the second on Wednesday morning, will be devoted to the Exposition. This arrangement, so successfully followed in 1952, assures full opportunity for all in attendance to obtain maximum benefit from a leisurely and studious inspection of the various exhibits.

Special Session for Operating Men

Truly, no operating man can afford to miss the forthcoming Chicago meeting, for in addition to the Exposition a special session has been arranged for Tuesday morning, which will be exclusively devoted to operating problems. This will be in the form of a panel discussion of carefully selected topics, with time allowed following each presentation for a question and answer period. A geographically representative committee of Operating Men devoted a full day to the selection of appropriate topics and speakers. As may be judged from the following, it is believed that the subjects chosen will prove of very real interest and practical value.

The session will open with a discussion by W. F. Alford of Consolidated Quarries Corporation, Decatur, Georgia, on the subject "New Developments in the Field of Quarry Drilling." Howard D. Perry, Southwest Stone Company, Dallas, Texas, will then discuss "Warehousing Problems Dealing With Inventory, Control of Stocks, Etc." "Selecting the Proper Screen Deck to Meet Specifications" will be given by Montagu Hankin, Jr., North Jersey Quarry Company,

Summit, New Jersey. E. Burwell Ilyus, Consulting Engineer of Roanoke, Virginia, will give us the benefit of his knowledge on the important subject "Chute Design." Mindful of the importance of safety in quarry operations, and the remarkable accomplishments in this field of the Inland Lime and Stone Company of Manistique, Michigan, John W. Moffatt, of that company, will discuss "The Place of the Superintendent in the Prevention of Accidents."

The last presentation "Tricks of the Trade" will be given by Edward J. Nunan, Federal Crushed Stone Corporation, Buffalo, New York. Member companies have been requested to send in brief articles, illustrated where possible, of unusual and effective tricks of the trade which will be consolidated into one presentation by Mr. Nunan. A review of the several articles so far received, indicate that here, indeed, may lie a gold mine of highly useful and practical information. Under the competent Chairmanship of George D. Lott, Jr., this session should prove to be an outstanding feature of the Chicago meeting.

Other Program Highlights

The program for the general sessions of the Convention has been carefully and thoughtfully developed by the Convention Arrangements Committee under the capable Chairmanship of Otho M. Graves. An excellently attended meeting of this Committee devoted a full day to a consideration of appropriate subjects and speakers, and delegates to the Chicago meeting are assured of an unusually well balanced program of basically important talks presented by nationally known authorities.

Full details of the program will be released shortly, pending which the following short preview should give emphasis to the fact that quarry operators and others interested in the crushed stone industry should let nothing interfere with their presence at Chicago.

Then too, there is a very special reason for bringing the salesmen to Chicago, and that reason is Ralph W. Carney, retired Vice President in Charge of Marketing, Coleman Company, Inc., Wichita, Kansas. With the salesmen particularly in mind, we have on several occasions in the past invited Mr. Carney to address our Annual Meeting, but, for one reason or another, up until now it has been impossible for him to accept. It is with a deep sense of gratification, therefore, that we can report that Mr. Carney will be the feature speaker at the opening session of the Convention on Monday, February 22. A dynamic personality, a gifted speaker, a man you will never forget, Ralph Carney talks the language of the businessman. His enthusiasm is contagious and he speaks with a background of over thirty years of successful selling and teaching others how to sell. His address to us on "Selling to Defend America" will prove inspiring and informative, and is certain to make a lasting impression.

The Greeting Luncheon on Monday, the opening day of the Convention, this year falls on George Washington's birthday, February 22, and it therefore seems especially appropriate that the subject of the luncheon address be "The Constitution is Your Business" Do not expect a dry and legalistic dissertation on what is generally recognized as a matter of very great and increasing importance to every American citizen, for this address will be made by Clarence Manion, who has gained a national reputation as a dynamic and inspirational speaker of unusual talent. Because of his speeches and writings on Americanism, Mr. Manion has won wide fame throughout our country, having received a Freedom's Foundation award in 1949 and again in 1950. Since 1941, Mr. Manion has been Dean of the University of Notre Dame College of Law, relinquishing this post in 1952 to give full time to his law practice, and is perhaps most widely known as the author of the recent best-seller "Key to Peace." With his speaking engagements definitely limited, in view of his recent acceptance of President Eisenhower's invitation to be Chairman of the Congressional Commission on Intergovernmental Relations, the Greeting Luncheon on Monday affords you a rare opportunity to hear this outstanding American personality.

During the deliberations of the Convention Arrangements Committee, it was interesting to note the strongly expressed opinion that in view of America's inescapable role in world affairs, it was highly desirable to have on the program a speaker well qualified to discuss the place of America in the world situation. After a careful examination of many candidates, we feel especially fortunate in having obtained Richard Thomas, who on Tuesday afternoon will address us on the subject of "America, the Constructive World Force." Mr. Thomas has been a foreign correspondent in Europe, Asia, and Africa, was radiocaster in the Mediterranean theater under General Eisenhower and an air force intelligence officer in the Pacific under General MacArthur. He is currently on the staff of the New York Times. Mr. Thomas has just recently returned from

a month abroad and we can therefore expect from him a searching and helpful analysis based on first-hand information.

Now here, truly, is a big surprise, as the speaker for the general luncheon on Wednesday will be a lady, and you can be sure that when this was suggested at the meeting of the Convention Arrangements Committee it provoked real discussion. The lady in question is Miss Lucile La Chapelle, and she was selected with enthusiasm after learning of the many highly complimentary observations made by a large variety of groups which had heard her. She will talk on the subject "You Are Better Than You Sound" and is known as one of the outstanding and versatile women speakers in the country today. Her presentation is humorous, charming, and intelligent; for something entirely different, be sure that you and the ladies in your group attend the Wednesday luncheon.

The NCSA Banquet climaxes the three-day Annual Convention and will be held on Wednesday evening, February 24. Having in mind that the purpose of this affair is to bring everyone together at the closing event of the Convention for an evening of sociability, inspiration, and entertainment, the Convention Arrangements Committee gave special attention to the selection of an appropriate speaker for the Banquet. Many candidates were screened, resulting in one who seemed outstandingly desirable. Plans were made for two "scouts" from our membership to attend a function where the proposed candidate was to speak, and we awaited with intense interest the verdict. It was enthusiastically favorable and, accordingly, arrangements were immediately completed to have as our Banquet speaker, Jeff H. Williams, known far and wide as "Oklahoma's Ambassador of Good Will." Jeff Williams will address us on the intriguing subject "Behind and Beyond Today." His solid belief in and devotion to the good old fashioned virtues is like a breath of fresh air amid all the "isms" and problems and theories of modern America. Mr. Williams has a real message for us and wraps it in a delightful package of wit, humor, and human understanding. He is one of America's greatest humorists and philosophers and the privilege of hearing him will be a delightful and memorable experience.

Something Has Been Added for Monday Evening

Monday evening affords the first opportunity for everyone present to get together for the highly desirable objective of simply having a good time, and something has truly been added to contribute to your enjoyment. Beginning with the customary cocktail party and buffet dinner at 6:30 p.m., arrangements have been made for a dance orchestra for the benefit of those who like to engage in the Terpsichorean art. As in the past, however, for those who are not particularly intrigued with the idea of dancing, the NCSA headquarters suite will be open throughout the evening, with everyone most cordially invited to drop in whenever it best suits his pleasure.

The Ladies Are Most Welcome

It goes without saying that we thoroughly enjoy having the ladies attend the Annual Convention in full force. We propose to do everything possible to insure that the ladies at Chicago will long and pleasurably remember their attendance at our 37th Annual Convention. Through the cooperation of our member hostesses, Mrs. Harry A. Clark, Mrs. Irwin F. Deister, and Mrs. M. E. McLean, an unusual program of entertainment for the ladies is rapidly nearing completion. It will be different and, we believe, most appealing.

A Cordial Invitation To All

This forthcoming 37th Annual Convention of the National Crushed Stone Association is not restricted to members only and we cannot emphasize this point too strongly. All crushed stone producers and others interested in the crushed stone industry are cordially invited to attend. We urge, if you have not already done so, that hotel reservations immediately be made with The Conrad Hilton. Special reservation cards are available upon request to the Association, and their use will insure preferential consideration in obtaining rooms for the Convention period.

Plan now to share with your fellow producers the many benefits and pleasures of the annual meeting.

NCSA Bulletin 11

A Method of Proportioning Concrete for Strength, Workability, and Durability

Revised November 1953 to include latest developments in this field

Single copies available upon request to NCSA

General Characteristics of Concrete Cracking[1]

By L. Boyd Mercer, M. C. E.

Chief Engineer
Ready Mixed Concrete Ltd.
Melbourne, Australia

CRACKING is now one of the most serious problems in concrete construction and is the subject of frequent discussion among engineers. The matter was considered at the 1950 Convention of the American Concrete Institute and the views expressed are of special interest as indicating the trend of opinion.

Professor Davis stated that modern construction practices are the cause of many of the problems associated with cracking. "In more recent years, we have been bound to the goal of high-strength, fast setting, fast drying concrete." He said that less cracking was found in the low-cement concrete which gains strength slowly. Miles N. Clair asserted that "we cannot prevent cracks but we can control them." W. H. Price, U. S. Bureau of Reclamation, said that there were so many causes of cracking—fineness of the cement, temperatures, alkali-aggregates reaction, foundation conditions, etc.—that one should never try to explain a crack.

Arsham Amerikian, head designing engineer, Bureau of Yards and Docks, Navy Dept., U. S. A., in an article "Extent and Acceptability of Cracking in Precast Concrete Framing Members," Journal of the American Concrete Institute, May 1950, stated:—

"In conventional or poured-in-place concrete construction, cracking does not contribute too serious a problem. For one thing, no significant cracks develop during construction to cause concern in inspection. Cracks which develop later under service conditions, are generally taken as natural occurrences, something about which little can be done."

The author disagrees with the general attitude of resignation to the problem of cracking; he endeavored to present the relationship and interconnection of different types of cracks by means of the diagram in an article "Classification of Concrete Cracks," "Commonwealth Engineer," September 1946. Attempts should be made not only to classify cracks but to detect causes, and to apply remedial measures.

1 Reprinted from *Commonwealth Engineer*, September 1951.

Types of Concrete Cracks

The various types of concrete cracks may be briefly summarized as follows:

I. Before-hardening

A. Constructional Movement
- (a) Subgrade
- (b) Formwork

B. Settlement Shrinkage
- (a) Reinforcement or similar obstructions
- (b) Aggregate

C. Setting Shrinkage
- (a) Plastic shrinkage
- (b) Drying shrinkage
  - (i) Rapid
  - (ii) Slower stage

II. After-hardening

A. Physical
- (a) Drying shrinkage
- (b) Moisture movements

B. Chemical
- (a) Cement and carbonation
- (b) Reactive aggregates
- (c) Foreign bodies and rust

C. Temperature
- (a) Internal temperature stresses
- (b) Thermal properties of aggregates
- (c) External variations
- (d) Frost and ice action

D. Stress Concentrations
- (a) Reinforcement
- (b) Structural form
- (c) Creep

E. Structural Design

F. Accident

The above subdivisions with descriptive explanations, probable causes, examples, and suggested remedies are discussed in the following:

I. Before-Hardening

This major subdivision is purely arbitrary and for the purpose of this classification is intended to extend from the time of placing the concrete up to the time when it has attained sufficient strength to resist alteration in form. In practice this may be regarded as from 2 to 8 hr after placing, for normal cements under normal temperature and curing conditions.

I.A. Constructional Movement

Concrete cracking necessarily occurs whenever the forces acting create stresses that exceed the tensile strength of the concrete. Insomuch as the tensile strength is very low in the early stages of the setting and hardening process, relatively small forces caused by constructional movement can cause cracking.

I.A. (a) Subgrade Movement (See Figure 1)

The principal causes of subgrade movement are moisture movements or insufficient compaction. The transfer of water from the concrete to a dry subgrade presents an example of the type of moisture movement experienced. The author has seen instances of such cracking when the concrete had been poured on building paper laid over a somewhat irregular subgrade. Soon after pouring, and just as the top of the concrete was setting, the damp paper subsided into hollows over which it had previously been taut, the result being the opening of wide cracks in the surface of the slab. The solution lies in adequate control of the subgrade.

I.A. (b) Formwork Movement (See Figure 2)

Movement of the boundaries of the concrete during the early setting period can create stresses because of removal of the support required by the wet concrete. Such movement can occur as a result of:

Spreading of forms because of swelling of timber with moisture.

Loosening of nails through tapping and vibrating the moulds to improve the stripping of surfaces.

Incorrect design of forms to accommodate pressure of the wet concrete.

The solution lies in proper design and construction of formwork.

I.B. Settlement Shrinkage

When the concrete is placed in position, and before setting of the mass takes place, the solid particles of aggregate settle and stabilize themselves through

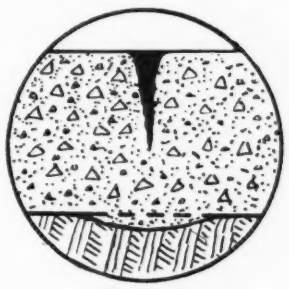


FIGURE 1
Crack Caused by Constructional Movement Downward of Subgrade

FIGURE 2
Movement of Formwork, e.g. by Swelling of Timber, Can Cause Cracking

point contact—contrary to the loosely used statement that the aggregate "floats in the paste." Continued settlement within the skeleton of these larger particles can result in mortar settlement and ultimately in accumulation of water at the upper surface or "water gain." Now if the conditions are such that the upper surface of the concrete becomes partially set while the interior is still settling, and if the interior contains some rigid obstacles such as reinforcing bars, then the interior will settle around these bars and cause cracks in the partially set concrete more or less vertically above these bars.

I.B. (a) Shrinkage around Reinforcement or Similar Obstructions (See Figure 3)

As outlined above, settlement shrinkage can cause cracks directly over obstructions. Correction of the trouble is theoretically possible by the introduction of early curing in order to delay the setting of the upper surface until the interior has set. However, this is generally impractical. Efforts at such curing are more likely to be mistimed and to succeed only in aggravating the trouble by chilling the surface and causing temperature shrinkage cracks. Adoption of dense plastic mixes with suitably graded aggregates, low water content, and adequate compaction of the concrete will generally prevent such cracking. In the event of cracking occurring in spite of the above precautions, as can occur with coincidences of climatic, structural, and mix conditions, the solution lies in postponement of the final floating until internal settlement has occurred.

I.B. (b) Shrinkage Around Aggregate Particles (See Figure 4)

This cracking manifests itself around aggregate particles which form a skeleton through which the paste settles and separates. The solution lies in the

use of dense plastic mixes, low water content, and suitably graded aggregates as given above.

I.C. Setting Shrinkage

Setting shrinkage can be considered in two stages—plastic shrinkage and drying shrinkage. The drying shrinkage can in turn be regarded in two stages:

(1) While the mass is plastic, the rate being rapid and depending upon the rate of evaporation and hence humidity conditions.

(2) A slower stage extending over the entire period of drying out.

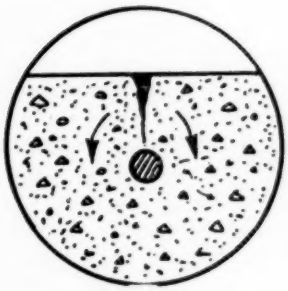


FIGURE 3
Shrinkage of Concrete Around the Reinforcement Is a Possible Cause of Cracking

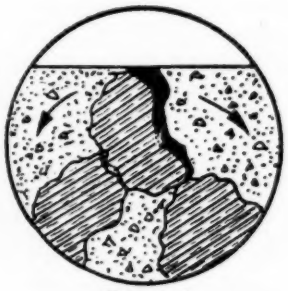


FIGURE 4
This Shows How a Crack May Be Formed by Shrinkage Around Aggregate

Thus the second stage overlaps from the before-hardening to the after-hardening. The problem of minimizing this shrinkage is primarily a matter for the cement manufacturers—the users can only adopt temporary expedients.

I.C. (a) Plastic Shrinkage

This phenomenon may appear as a giving-off of water, and it has been suggested that the action may be related to that of syneresis which has been described by F. M. Lea and C. H. Desch in "The Chemistry of Cement and Concrete," as follows:

> "When hydrochloric acid is added to sodium silicate solution, silica gel is precipitated. This freshly prepared gel is unstable and begins to shrink, expelling water from the mass, undergoing a process known as syneresis. During syneresis no volume change occurs in the whole system (gel plus water), and the process consists simply in the expulsion of free liquid enmeshed in the gel, the shrinkage of the gel reducing the available pore space."

Syneresis comes to an apparent end when the water content of the gel is still very high—about 90 per cent.

The phenomenon may also be caused by "false set," (see the paper, "False Set in Portland Cement," by R. F. Blanks and J. L. Gelleland, "American Concrete Institute Journal," March 1951), in which case the solution may be in holding down the grinding temperature through the use of coal clinker and water sprays on the mills or else the use of a stable form of calcium sulphate, either natural or artificial.

These cracks occur very soon after placing and finishing, sometimes within a matter of minutes, and can occur under moist conditions—even under a film of water. A characteristic of the cement is believed to be the cause of this trouble and the only immediate solution when it occurs appears to be delayed finishing—pressing the plastic concrete to close the cracks. When this has been done, they do not reappear. An instance was quoted in the above paper in which the stiffening of the cement was relieved and cracking reduced by increasing the SO_3 to 2.5 per cent.

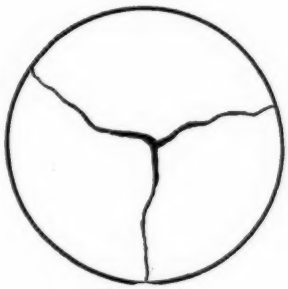


FIGURE 5
Typical Three-branched Crack Resulting From Drying Shrinkage

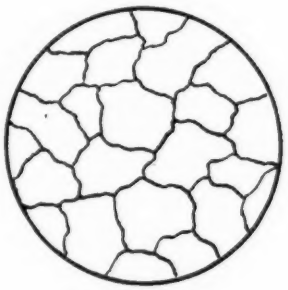


FIGURE 6
Crazing of Concrete From Reaction of Cement with Carbon Dioxide of Air

I.C. (b) Drying Shrinkage (See Figure 5)

The shrinkage of concrete upon drying is governed by the gelatinous constitutents of the cement. Moisture is held in the pores of the gel by certain forces of attraction but when the water is removed then these forces draw the atoms of the gel closer. Cracking caused by drying shrinkage can thus be prevented by retention of the water.

I.C. (b) (i) Drying Shrinkage—Rapid Stage

This cause of cracking which occurs while setting is in progress, is difficult to distinguish from the loss of water from the cement gel with thinning of

the films separating particles, but is regarded for the purpose of this classification as a pulling together of the solids by surface tension. When water wets the cement and aggregate particles it spreads and creates an air-water surface. As the mix dries out, air is drawn into the mass to replace the water, with the result that some reduction occurs in the air-water surface and this causes the particles to be drawn together with resultant shrinkage of the concrete.

Examples of such cracking can be observed whenever freshly poured concrete pavements are exposed to a high wind, low humidity, or hot sun with temperature differential between the mass and the surrounding air. It is important to appreciate the importance of humidity in evaporation. For instance, while air at 30 F may be saturated with moisture, (i.e. have 100 per cent relative humidity) if it is warmed to 70 F the relative humidity will be reduced to about 25 per cent and the air will be quick to draw moisture from the concrete. Prevention lies in covering the concrete with damp sand, burlap, or straw, which, like ponding with water are messy. The materials must be put on at just the right time to avoid marking the surface and then they must be prevented from blowing around. A common method has been to sprinkle the surface with water, which in the case of hot, sunny weather may mean the use of fine fog sprays within one hour of placing. This has attendant disadvantages such as the need for very careful supervision and the danger of "chilling" the surface thus increasing the danger of cracking. Liquid membranes, emulsions, black coal-tar compounds, and asphalt cut-back materials, clear compounds of the paraffin type, and white and fading pigmented compositions have made their appearance and serve a very useful purpose. None is as effective as moist curing which serves to replenish the water loss.

An additional cause for such drying shrinkage can be water loss into the subgrade, as distinct from the above which is primarily caused by evaporation. The subgrade must be damp and not free draining to the point where it can let water escape. Properly controlled, the preliminary watering of the subgrade can serve as a reservoir for curing water by capillary action.

I.C. (b) (ii) Drying Shrinkage—Slower Stage

This cause of cracking presents the link between the before-hardening and after-hardening stages insomuch as the shrinkage continues throughout the entire drying period. It is caused by the shrinkage of the gel with loss of water and necessarily occurs in all concrete which must ultimately dry out. Reduction in the cement and water content of the mix with adequate curing to permit complete hydration minimizes the amount of shrinkage. It is this particular form of shrinkage as a cause of cracking which has led to such statements as—

"It shrinks as it dries."

"We cannot prevent cracks but we can control them."

II. After-Hardening Cracks

Ramifications of this group of cracks is very considerable; the group is intended to include all those cracks that can occur in concrete after passing to the arbitrary stage of being able to resist alteration to form. Thus the group extends from the early-setting and hardening period throughout the entire life of the structure or work.

II.A. Physical

This group covers cracking caused through movement of the gel with variations in water content.

II.A. (a) Shrinkage after Hardening

This corresponds with the above "Slower Stage of Drying Shrinkage," as given under IC. (b) (ii) above and continues throughout the entire drying period.

II.A. (b) Moisture Movements

As dealt with in the author's article—"Volume Changes Resulting from Moisture Movements in Set Concrete," "Commonwealth Engineer," June 1950, subsequent wetting of concrete after drying presents a reversible action that is comparable in magnitude with the original shrinkage. Thus structures that are subject to alternations of wetting and drying must have provision for such movement or in some way be able to withstand the very considerable stresses which are set up—otherwise cracking must occur. The presence of obstructions, such as reinforcing bars, can aggravate and expedite this type of failure. Another example of cracking that can occur through moisture movements is in the rare case of some inferior and porous aggregates, while a further elaboration of such trouble can be observed where a dry timber peg becomes embedded in the concrete and with expansion upon wetting, cracks the surrounding concrete.

II.B. Chemical

This includes cracking not only from reactions within the constituents of the concrete but also from the presence of foreign bodies.

II.B. (a) Cement and Carbonation (See Figure 6)

This deals with the result of chemical reactions from the incorporation of active constituents through excess of lime, magnesia, or sulphates, and the effect of carbonation.

Incomplete combination of the lime with the other raw constituents in cement manufacture, through underburning of the clinker, results in free or uncombined lime in the finished product with possible resultant expansion and disruption. Magnesium oxide, a minor constituent in most raw materials, can cause excessive expansion if the concrete is moist. Excesses of calcium sulphate (gypsum) can also cause cracking. These constituents of the cement are limited by specifications while the soundness and pat tests can present illustrations of the harmful effects.

Carbonation occurs when cement is exposed to the carbon dioxide of the air and is illustrated by the numerous examples of crazing to be observed especially on cement rendered surfaces.

II.B. (b) Reactive Aggregates

Cracking can result from the inclusion of chemically active constituents in the aggregates—pyrites present an example of such constituents.

Much investigation has been carried out in recent years upon the expansive reaction between certain aggregates and high alkali cements following upon the serious cracking that occurred at the Parker dam in U.S.A. In spite of all efforts to produce high quality concrete, and the observation of every precaution considered necessary to secure good work, the concrete 2 1/2 years after completion was found to be deteriorating. The outside concrete skin to a depth of 2 1/2 ft from the surface was shrinking, from 2 1/2 ft below the surface it was expanding slightly, and from 5 to 10 ft below the surface it was expanding considerably. The picture thus presented was of a large expanding interior mass of concrete, the thin outer shell of which was contracting. Suspect aggregates were found to include such aggregate types as shale, siliceous limestone, andesite, granite, gneiss, rhyolite, felsite, chert, and phyllite. California siliceous magnesium limestones and opaline quartzite (gibber) were shown to be definitely reactive and a limitation of 0.5 to 0.6 was set for the alkalies, sodium oxide and potassium oxide, in the cement, to safeguard the performance of the structure where suspect aggregates were used.

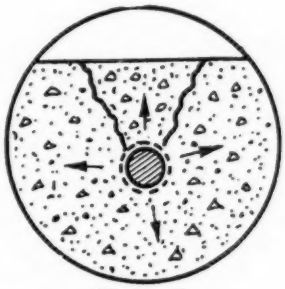


FIGURE 7
Cracking Resulting From Pressure Exerted by Oxidation of the Reinforcement

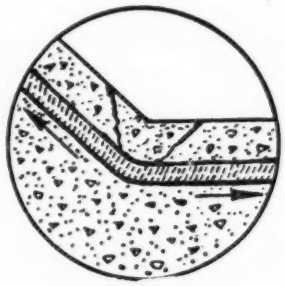


FIGURE 8
Cracking Due to Stress Concentration at the Bend of a Reinforcement Rod

II.B. (c) Foreign Bodies and Rust (See Figure 7)

Chemical action between the concrete and various metals which are at times embedded in the concrete, such as zinc coated or aluminum bolts, can cause expansion and cracking. However, the most frequent example of such trouble is in the oxidation of mild steel reinforcing bars. Such failures may be classified as design or construction failures through inadequacy of cover or permeability of the concrete. The trouble generally occurs where the structure is subjected to alternate wetting and drying, especially in presence of sea-water.

II.C. Temperature

The heat generation of cement is connected with fineness, and composition of the cement presents a problem for the cement manufacturer. The thermal co-efficient of expansion and contraction for concrete on the other hand varies with the richness of the mix, type of aggregate, water content, and other factors. Provision must always be made for structures to be designed and constructed in units with dimensions which permit volume adjustment with temperature change, or else provide for absorption of the stresses consequent upon restraint.

II.C. (a) Internal Temperature Stresses

Much work has been done to prevent cracking resulting from the differential temperature caused through the heat of hydration of cement. The work has largely been confined to the more extensive mass concrete construction as in dams and has resulted in limitations on the heights of pours and periods

between successive lifts. The precautions have also included the use of low-heat cement, the addition of cracked ice to the mix, and elaborate cooling water systems including the use of refrigeration. (See article "Refrigeration Plant for Cooling Concrete at Warragamba," "Commonwealth Engineer," June 1, 1951, p. 425).

II.C. (b) Thermal Properties of Aggregate

In some structures in America, incorporation in the mix of aggregates that have vastly different thermal properties from those of the matrix has been demonstrated as a cause of cracking with resulting lack of durability.

II.C. (c) External Temperature Variations

Provision must necessarily be made for the concrete to withstand the stresses or be provided with expansion joints to correspond with a thermal coefficient varying from 5.0 to 7.5 millionths, depending upon the mix and materials.

II.C. (d) Frost and Ice Action

Penetration of water into the outer pores or openings, and subsequent freezing with resultant cracking and spalling of sections from the structure, can be prevented by the use of dense impermeable concrete in a design free from places for lodgment of water.

II.D. Stress Concentrations

The usual assumptions in reinforced concrete design and the frequent need for photo-elastic stress analysis, on account of irregular shapes and sections of members, can increase design difficulties.

II.D. (a) Reinforcement Stress Transfer (See Figure 8)

Test loading upon reinforced concrete beams shows the occurrence of cracks in three stages:

(1) Up to the time when the elongation or stretch of the concrete is equal to the ultimate stretch of plain concrete.

(2) While tension is resisted by steel and by portion of the concrete between the end of the crack and the neutral axis.

(3) After materials pass their elastic limit.

Although cracks in the first stage are minute and not visible to the naked eye, the fact remains that some cracking must necessarily occur in reinforced concrete before the structure can function as designed. This disadvantage disappears when the steel is either prestressed or poststressed.

Deformed reinforcing bars will present stress concentrations at the irregularities and it is appreciated that this can cause numerous fine cracks; these are preferable to the larger ones occurring where plain bars are used. Bent reinforcing bars cause stress concentrations in the concrete at the points of direction change and can result in cracking where there is insufficient depth of concrete or anchorage to withstand the forces.

II.D. (b) Structural Form (See Figure 9)

Square openings or re-entrant angles present considerable concentrations of tensile stress necessitating suitably placed reinforcement as can be demonstrated by the use of photo-elastic models. The cracking at corners of door and window openings presents an example of this trouble.

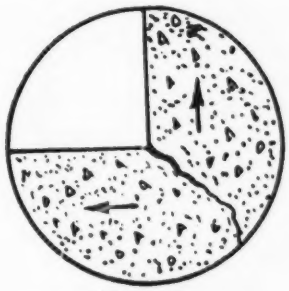


FIGURE 9
Crack at Angle Resulting From Concentration of Tensile Stress in Concrete

II.D. (c) Creep

Concrete yields under sustained load beyond the immediate deformation accompanying application of the load and this "plastic flow" or "creep" has been known to continue for as long as 10 years. This presents an unlikely cause for cracking but can perhaps be contributory under some conditions of design, reinforcement, and load.

II.E. Structural Design

Design loadings and stresses can generally be checked for superstructures against actual loads, conditions, materials, and quality of workmanship. However, it is frequently more difficult to locate and assess the effect of foundation behavior—foundation settlement presenting a common cause of structural concrete cracking.

II.F. Accident

Finally, we must consider cracking as the result of accidental over-load, excessive vibration beyond any provision in design, and the effect of the elements—fire, storm, and even earthquake. The above are generally obvious as a cause of failure although instances have occurred where the trouble has been traced to the result of blasting in the vicinity.

General Conclusions

It is apparent from the above survey of the numerous causes of cracking and the considerable care necessary for prevention that the problem is of major importance in concrete construction.

Developments such as prestressing and poststressing can provide an immediate expedient in many cases.

However, much can still be done in cement manufacture to reduce shrinkage and heat generation; much can be done in design and construction to avoid excessive tensile stresses.

Fewer Highway Dollars Diverted to Non-Highway Purposes in 1952

A substantial reduction in the total amount of highway use tax revenues diverted by the states to non-highway purposes in 1952 is shown by a National Highway Users Conference analysis of figures recently released by the Bureau of Public Roads.

Twenty-five states and the District of Columbia spent a total of $202.8 million of highway use income for other-than-highway purposes—some 24 per cent less than the amount diverted in 1951.

When compared to total tax revenues collected by all the states from road users, this 1952 diversion figure means that an average of 6.5 cents out of every highway use dollar was expended for non-highway purposes, as compared to 9.3 cents diverted in the previous year.

Despite the progress shown by the analysis, it also discloses that diversion continues to be a serious problem in a number of states. In Delaware, for example, 42 per cent of the net highway use tax receipts were diverted. Rhode Island's diversion amounted to 40 per cent. In Florida, which ranked third percentagewise, $25.3 million (or 25.2 per cent) was used for non-highway purposes. Much of this amount was made up of license fees which, because of an amendment adopted at the last election, must be diverted to uses totally unrelated to the maintenance and construction of needed highways.

Twenty-four states have adopted anti-diversion constitutional amendments to date and the great value of such protection is reflected in the 1952 figures. In past years, Georgia has consistently diverted large portions of its highway use income. An anti-diversion constitutional amendment was adopted in that state last year and Georgia's diversion in 1952 amounted to zero. The adoption of a similar amendment in Alabama should reduce or wipe out the $2.45 million diversion figure reported for that state in 1952.

Greater Farmer Dependence on Roads

THE American farmer's increasing dependence on highways over the past quarter of a century is evident in the statistics of the 1950 census, featured in a recent bulletin of the Department of Commerce.

The bulletin reports that of 5.1 million farms classed by kind of access road, 1.6 million were located on hard-surfaced roads, 1.8 million were located on gravel, shell, or shale roads, and 1.7 million farms were located on dirt or unimproved roads.

In 1950, the report continues, two in three farms were located on hard-surfaced, gravelled, or other improved all-weather roads as compared with about one in four in 1925. In 1950 one in three farms was located on dirt or unimproved roads, while in 1925, 77 in 100 farms were so located.

The census also revealed that the average American farm family travels six miles to do its shopping, based on information collected from farmers who reported on the distance travelled to the trading center they visited most frequently.

Nearly two-thirds of all farms had automobiles in 1950, with 3.4 million farms reporting a total of 4.2 cars. The average age of the newest model farm automobile was eight years.

Slightly more than one-third of the farms had a motortruck and the average age of the newest model truck was eight years. One in twelve farms had a motortruck but no passenger automobile.

Information about farm facilities, roads, trading center, and equipment is presented in Volume II, Chapter 3, General Report, 1950 Census of Agriculture. ——*Highway Highlights*, September-October 1953

The Importance of Developing a Realistic National Program for Highway Construction[1]

By GEN. EUGENE REYBOLD

Executive Vice President
American Road Builders' Association
Washington, D. C.

IT is a great pleasure to be with you on the occasion of your annual meeting and I am honored in having a place on your program with the highway leaders of your state. The outstanding progress on your turnpike is being watched throughout the nation and your half-billion dollar bond issue to finance arterial highways and urban extensions is most gratifying to all of us who are promoting better roads throughout the country.

You have set an example and the time has now arrived when action must be taken in other places to relieve the increasing pressure for safe and efficient highway transportation. The situation calls for bold and decisive action, not only in the states and cities, but nationally as well. Here in Ohio you have done just that. You have met the call and there is every reason to believe that you will be rewarded with commensurate dividends. Your public officials, both legislative and administrative, together with all those who supported this forward movement in road building, are to be congratulated.

In Washington the authorities have been well briefed on mounting traffic volumes and congestion and they are aware that our overburdened, often obsolete and deteriorating highway plant needs modernizing to handle the load. Our whole economy and social system is now so closely geared to motor transportation that procrastination on vital highway improvements is inexcusable. The economic cost of traffic accidents and tie-ups is already far too high. On top of this are defense requirements that cannot be ignored.

Financing is the Big Issue

In brief, there seems to be little question in Washington about highway needs, but there is a very big question on how to meet those needs. Financing is, of course, the big issue and there is no solution short of tackling the job in a large and realistic manner. The national interest was established by Congress some 37 years ago and jointly the federal and state authorities have done a splendid job in selecting the highway network representative of that interest. I refer to the Federal-Aid Highway Program established by law in 1916. In furtherance of that program we, in the American Road Builders' Association, maintain that ways and means must be found for an accelerated schedule of construction. A piecemeal approach is not the answer if we are to catch up and stay up.

During the past year there have been various criticisms, some of them outright charges, against national highway planning and the federal-aid program itself. Several of our Governors have suggested curtailment or abolishment of federal assistance to the states and communities in road construction. While this is not the time nor place to challenge this proposal, ARBA strongly supports the federal-aid highway program as a coordinated 48-state plan with initiation and responsibility for projects lodged in the states and localities. We favor its continuation and expansion as being in the interests of the general welfare and the common defense.

Proposals to Change Federal-Aid Program Now Being Studied

Proposals to drastically change or curtail the federal-aid program are now being studied by a special Commission on Intergovernmental Relations, authorized by Congress and named by the President. The Commission is due to report to Congress by March 1, 1954.

[1] Presented before the Ohio Contractors Association, Neil House, Columbus, Ohio, December 8, 1953.

Even before this Commission began its work, the related problems were scrutinized in special hearings conducted last summer by the House and Senate Subcommittees on Roads. The American Road Builders' Association was invited to present its views to both subcommittees and President Reindollar and I appeared and made definite recommendations. We pointed out that a piecemeal or timid approach to the problem would be shortsighted and only add to the confusion and acuteness of the whole situation. We took the position that the time is now ripe for a re-evaluation of the federal-aid highway program with a view to a definite determination of its future role in support of the nation's economy and the national defense. We recommended to the House and Senate members that Congress authorize appointment of a joint committee to conduct a thorough investigation of the entire national network of highways, including the federal-aid system of interstate, primary, secondary, and urban highways, together with a concurrent study of ways and means of financing requirements on the federal-aid system based on a 10-year program for the correction of deficiencies.

The AASHO, at the close of 1951, estimated it would require $32 billion to correct deficiencies in the federal-aid system and that figure can be revised upward to at least $40 billion in view of increased costs and other contingencies arising in a 10-year program if such a program be adopted.

Long-Range National Program Highly Desirable

Actually, a well-planned, long-range federal-aid program would be immensely helpful to the state highway departments, enabling them to plan into the future. Furthermore, it would establish a stable work load that would permit contractors and others in the highway field to proceed in their competitive operations with confidence. Rigid programs are not desirable of course, but continuity of work does have a stabilizing effect in leveling off the peaks and valleys so characteristic of the highway industry.

The federal-aid highway program for years has directly and indirectly served the highway construction industry well and those of you in the business have every right to a selfish interest in continuation and expansion of the program. Believe it or not, 99 per cent of all federal-aid projects are constructed by the contract method and you know that that fact in itself is having a salutary effect throughout the industry. If I may make a personal observation at this point, I had the responsibility as Chief of Engineers of the Army during the last war of handling over $11 billion of work by contract. I had always known, and I had it re-emphasized to me then, that the contract method is the only satisfactory way of getting a big job done and done right. I remain a consistent champion of the contract method not only for new construction but for major maintenance work as well. In this regard, AASHO has undertaken a significant study of the whole contract maintenance problem. The study was proposed by the ARBA-AASHO Cooperative Committee in 1952 and a subcommittee of state officials was set up. A correlative body, the Committee on Development of Contract Maintenance Work, was established by ARBA to cooperate. We are gratified with the initial report made last month by Mr. McCaughey in which he outlined the results of an investigation covering current practices in the 48 states in contract maintenance operations. This is a real step in the right direction and ARBA is only too glad to assist and is now developing additional activities of a cooperative nature.

At headquarters, we are frankly concerned right now with the general confusion that seems to exist in Washington with respect to charting a confident course toward highway progress. However, Congress will reconvene next month and with the subsequent submission of legislative recommendations by the Executive Branch, we should have a clearer idea of what may develop in planning and paying for the nation's roads.

As contractors, you will keep in mind the advantages that have come through standardization of design and construction brought about largely through national planning and the continuity and stability of contract work that will be made possible through a long-range, federal-aid program.

In conclusion, let me say that ARBA regards the primary task ahead to be that of developing a realistic national program for highway construction that will employ the contract method and continue responsibility in the hands of the states. Self-liquidating expressways are part of the answer at state levels, but states and communities cannot hope to satisfy more than a small percentage of their street and road requirements through financing by tolls. The ultimate answer lies in national planning and some degree of federal financial participation in a program national in character.

$575 Million Apportioned for Federal-Aid Highways

APPORTIONMENT of the $575 million authorized as federal aid to the states for highways in the fiscal year beginning July 1, 1954, was announced recently by Secretary of Commerce Sinclair Weeks. The funds were authorized by the Federal-Aid Highway Act approved June 25, 1952.

The Act provides $247,500,000 for projects on the federal-aid primary highway system, $165,000,000 for projects on the federal-aid secondary system, $137,500,000 for projects on the federal-aid primary highway system in urban areas, and $25,000,000 for projects on the National System of Interstate Highways.

The funds become available to the states as of January 1, 1954, and will be expended under supervision of the Department's Bureau of Public Roads according to the general procedure in use for many years in which state highway departments propose projects, prepare plans, award contracts, and supervise construction, all subject to federal approval. Federal participation is limited to half the cost except in the public-lands states where participation may be increased above 50 percent by one-half of the percentage of the area of the state that is public land.

Funds for the federal-aid primary highway system and interstate system are apportioned in proportion to area, population, and mileage of post roads, each being given equal weight. Funds for federal-aid secondary roads are apportioned in the same manner except that rural population is used rather than total population. Funds for urban projects are apportioned in proportion to population in municipalities and other urban places of 5,000 or more.

The apportionment of $575 million made after setting aside an amount for administration and research as authorized by law, is shown in the accompanying table.

State	Sums Apportioned For				
	Federal-Aid Primary Highway System ($247,500,000)	Secondary or Feeder Roads ($165,000,000)	Urban Highways ($137,500,000)	Interstate System ($25,000,000)	Total
Alabama	$5,254,353	$4,071,630	$1,767,190	$536,065	$11,629,238
Arizona	3,682,659	2,508,001	524,664	374,943	7,090,267
Arkansas	4,099,014	3,280,781	754,576	417,845	8,552,216
California	11,302,419	5,819,399	11,990,492	1,156,953	30,269,263
Colorado	4,430,632	2,959,462	1,121,056	451,275	8,962,425
Connecticut	1,596,556	804,375	2,612,362	163,779	5,177,072
Delaware	1,206,563	804,375	276,636	121,875	2,409,449
Florida	4,000,064	2,614,900	2,418,720	408,607	9,442,291
Georgia	6,093,832	4,654,049	1,965,808	621,611	13,335,300
Idaho	3,035,086	2,134,840	259,599	308,923	5,738,448
Illinois	9,485,889	5,165,722	9,433,309	970,391	25,055,311
Indiana	5,844,963	4,028,914	3,227,030	596,664	13,697,571
Iowa	5,946,365	4,351,647	1,601,372	605,903	12,505,287
Kansas	5,975,744	4,183,753	1,267,798	608,403	12,035,698
Kentucky	4,538,481	3,767,905	1,400,780	463,271	10,170,437
Louisiana	3,836,826	2,777,082	1,977,289	391,908	8,983,105
Maine	2,065,955	1,478,426	563,746	210,595	4,318,722
Maryland	2,164,618	1,323,108	2,289,281	221,739	5,998,746
Massachusetts	3,127,509	1,161,437	5,614,329	321,494	10,224,769
Michigan	7,641,646	4,662,919	6,277,985	781,229	19,363,779
Minnesota	6,385,910	4,508,055	2,196,488	650,982	13,741,435
Mississippi	4,401,911	3,666,740	746,808	448,780	9,264,239
Missouri	7,177,220	4,856,080	3,321,925	732,034	16,087,259
Montana	4,945,242	3,401,828	317,626	503,085	9,167,781
Nebraska	4,801,122	3,404,259	791,122	488,697	9,485,200
Nevada	3,179,310	2,124,823	102,729	323,336	5,730,198
New Hampshire	1,206,563	804,375	399,467	121,875	2,532,280
New Jersey	3,183,593	1,071,310	5,904,745	327,310	10,486,958
New Mexico	4,002,794	2,749,864	442,682	407,405	7,602,745
New York	11,573,650	4,637,841	18,029,580	1,187,586	35,428,657
North Carolina	6,101,355	5,211,948	1,733,316	622,886	13,669,505
North Dakota	3,572,139	2,593,772	228,084	363,355	6,757,350
Ohio	8,586,082	5,222,980	7,805,716	878,337	22,493,115
Oklahoma	5,269,114	3,772,951	1,473,687	536,936	11,052,688
Oregon	4,209,393	2,941,860	1,081,596	428,962	8,661,811
Pennsylvania	9,663,980	5,751,129	10,211,618	989,979	26,616,706
Rhode Island	1,206,563	804,375	964,266	121,875	3,097,079
South Carolina	3,315,477	2,745,191	927,881	338,411	7,326,960
South Dakota	3,845,626	2,746,570	261,991	391,167	7,245,354
Tennessee	5,335,882	4,158,793	1,950,550	544,484	11,989,709
Texas	15,972,097	10,694,852	6,462,029	1,628,769	34,757,747
Utah	2,830,795	1,872,691	571,559	288,296	5,563,341
Vermont	1,206,563	804,375	210,027	121,875	2,342,840
Virginia	4,676,730	3,634,841	2,103,426	477,631	10,892,628
Washington	4,070,327	2,719,183	2,035,293	415,444	9,240,247
West Virginia	2,685,059	2,337,564	877,871	274,317	6,174,811
Wisconsin	5,816,900	4,058,553	2,641,382	593,492	13,110,327
Wyoming	3,070,586	2,080,954	146,664	312,346	5,610,550
Hawaii	1,206,563	804,375	453,586		2,464,524
Dist. of Col.	1,206,563	804,375	1,165,310	121,875	3,298,123
Puerto Rico	1,278,217	1,335,768	1,159,454		3,773,439

Manufacturers Division — National Crushed Stone Association

•

These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

•

Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.
Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Tractors

American Cyanamid Co.
Explosives Department
30 Rockefeller Plaza, New York 20, N. Y.
Explosives and Blasting Supplies

American Manganese Steel Division
American Brake Shoe Co.
109 North Wabash Ave., Chicago 2, Ill.
Manganese Steel Castings, Power Shovel Dippers, Material Handling Pumps, Reclamation and Hard-Facing Welding Materials

American Pulverizer Co.
1249 Macklind Ave., St. Louis 10, Mo.
Manufacturers of Ring Crushers and Hammermills for Primary and Secondary Crushing

American Steel & Wire Division
Rockefeller Bldg., 614 Superior Ave., N. W., Cleveland 13, Ohio
Wire Rope, Aerial Wire Rope Tramways, Electrical Wires and Cables, Welded Wire Fabric, Concrete Reinforcing, Wire Nails, Fencing, Netting

Atlas Powder Co.
Wilmington 99, Del.
Industrial Explosives and Blasting Supplies

Bacon-Greene & Milroy
29 Washington Ave., Hamden 14, Conn.
"Farrel-Bacon" Jaw Crushers for Primary and Secondary Operations, Conveyors, Elevators, Rolls, Screens

Baldwin-Lima-Hamilton Corp.
Construction Equipment Division
South Main St., Lima, Ohio
Power Shovels, Draglines, Cranes, Bins, Conveyors and Idlers, Crushers and Pulverizers, Feeders, Plants—Crushing and Portable, Washing Equipment

Barber-Greene Co.
400 North Highland Ave., Aurora, Ill.
Portable and Permanent Belt Conveyors, Belt Conveyor Idlers, Bucket Loaders both Wheel and Crawler Mounted, Asphalt Mixers and Finishers, Coal Handling Machines

Buchanan, C. G., Crushing Machinery Division, Birdsboro Steel Foundry and Machine Co.
1941 Furnace St., Birdsboro, Pa.
Primary and Secondary Crushers and Rolls

Bucyrus-Erie Co.
South Milwaukee, Wis.
Excavating, Drilling and Material Handling Equipment

Buda Co.
Division of Allis-Chalmers Mfg. Co.
154th St. and Commercial Ave., Harvey, Ill.
Diesel and Gasoline Engines; Material Handling Equipment; Lifting Jacks; Earth Drills and Maintenance of Way Equipment

Cape Ann Anchor & Forge Co.
Whittemore St., Gloucester, Mass.
"Cape Ann" Forged Steel Drop Balls

Caterpillar Tractor Co.
Peoria 8, Ill.
Track-Type Tractors, Bulldozers, Earthmoving Scrapers, Motor Graders, Heavy-Duty Off-Road Hauling Units, Diesel Engines, and Diesel Electric Generating Sets

Chain Belt Co.
P. O. Box 2022, Milwaukee 1, Wis.
Rex Conveyors, Elevators, Feeders, Idlers, Elevator Buckets, Drive and Conveyor Chains, Sprockets, Bearings, Pillow Blocks, Power Transmission Equipment, Portable Self-Priming Pumps

Clark Equipment Co.
Construction Machinery Division
270 Miller St., Benton Harbor, Mich.
Truck Mounted and Crawler Shovel Crane, 3/8 and 1/2 Cu. Yd.

Continental Gin Co.
4500 Fifth Ave., S., Birmingham 2, Ala.
Conveyors—Belt, Screw, Flight and Underground Mine; Elevators—Bucket and Screw; Feeders—Apron, Belt, Reciprocating, Table, and Screw; Drives—V-Belts, Chains and Sprockets, Gears and Speed Reducers

Manufacturers Division—National Crushed Stone Association
(continued)

Cross Engineering Co.
P. O. Box 507, Carbondale, Pa.
Cross Perforated Steel Segments, Sections, Decks, for Vibrating, Shaking, Revolving, and Other Types of Screening Equipment

Cummins Engine Co., Inc.
Fifth and Union Sts., Columbus, Ind.
Lightweight Highspeed Diesel Engines (50-550 Hp.) for: On-Highway Trucks, Off-Highway Trucks, Buses, Tractors, Earthmovers, Shovels, Cranes, Industrial and Switcher Locomotives, Air Compressors, Logging Yarders and Loaders, Oil Well Drilling Rigs, Centrifugal Pumps, Generator Sets and Power Units, Work Boats and Pleasure Craft

Deister Machine Co.
1933 East Wayne St., Fort Wayne 4, Ind.
Deister Vibrating Screens, Classifiers, Washing Equipment

Detroit Diesel Engine Division
General Motors Corp.
13400 West Outer Drive, Detroit 28, Mich.
Light Weight, Compact 2 Cycle Diesel Engines and "Package Power" Units for All Classes of Service

Diamond Iron Works, Division of
Goodman Manufacturing Co.
1728 North Second St., Minneapolis 11, Minn.
Jaw and Roll Crushers; Vibrator, Revolving, and Scrubber Screens; Drag Washers; Bucket Elevators; Belt Conveyors; Bins; Apron and Plate Feeders; Portable Gravel and Rock Crushing, Screening, and Washing Plants; Stationary Crushing, Screening, and Washing Plants; Hammermills

Du Pont, E. I., de Nemours & Co.
Wilmington 98, Del.
Explosives and Blasting Supplies

Eagle Iron Works
129 Holcomb Ave., Des Moines 13, Iowa
Fine Material Screw Washers—Classifiers—Dehydrators; Coarse Material Screw and Log Washers—Dewaterers; Water Scalping and Fine Material Settling Tanks; Drop Balls—Ni-Hard and Semi-Steel; "Swintek" Screen Chain Cutter Dredging Ladders

Easton Car & Construction Co.
Easton, Pa.
Off-Highway Transportation: Dump Trailers, Truck Bodies, and Cars for Mines, Quarries, and Earth Moving Projects

Ensign-Bickford Co.
Simsbury, Conn.
Primacord-Bickford Detonating Fuse and Safety Fuse

Euclid Division
General Motors Corp.
1361 Chardon Road, Cleveland 17, Ohio
Heavy-Duty Trucks and Dump Trailers for "Off-Highway" Hauls. Loaders for Earth Excavation, Single and Twin Engine Earth Moving Scrapers

Even Spread Co.
P. O. Box 98, Owensville, Ohio
Power Spreaders and Attachments for Agricultural Lime and Fertilizer

Frog, Switch & Mfg. Co.
Carlisle, Pa.
Manganese Steel Department—Manufacturers of "Indian Brand" Manganese Steel Castings for Frogs, Switches, and Crossings, Jaw and Gyratory Crushers, Cement Mills, Mining Machinery, Etc., Steam Shovel Parts

General Electric Co.
1 River Road, Schenectady 5, N. Y.
Electric Motors, Controls, Locomotives, Welding Equipment, Coordinated Electric Drives for: Shovels, Drag Lines, Conveyors, Hoists, Cranes, Crushers, Screens, Etc.; Coordinated Power Generating and Distributing Systems Including Generators, Switchgear, Transformers, Cable, Cable Skids, Load Center Substations

Gill Rock Drill Co.
Lebanon, Pa.
Well Drill Tools and Supplies

Goodrich, B. F., Co.
500 South Main St., Akron 18, Ohio
Industrial Rubber Products — Flexible Bonded Edge Conveyor and Elevator Belting, Cord Conveyor Belting, Highflex and Cord Transmission Belting; Grommet V-Belts; Type 54 Air Hydraulic Control, Burst Proof Steam, Water, Suction and Other Hose; Armorite Chute Lining; Rubber and Koroseal Protective Clothing and Footwear; Tires and Tubes (Automobile, Truck, Off-the-Road, Industrial), Batteries

Manufacturers Division—National Crushed Stone Association
(continued)

Goodyear Tire & Rubber Co., Inc.
Akron 16, Ohio
Airfoam; Mechanical Goods—Belting (Conveyor, Elevator, Transmission), Hose (Air, Water, Steam, Suction, Miscellaneous), Chute Lining (Rubber); Rims (Truck and Tractor); Storage Batteries (Automobile, Truck, Tractor); Tires (Automobile, Truck, Off-the-Road); Tubes (Automobile, Truck, Off-the-Road, LifeGuard, Safety Tubes, Puncture Seal Tubes)

Gruendler Crusher and Pulverizer Co.
2915 North Market St., St. Louis 6, Mo.
Rock and Gravel Crushing and Screening Plants, Jaw Crushers, Roll Crushers, Hammermills, Lime Pulverizers

Gulf Oil Corp.
Gulf Refining Co.
Gulf Bldg., Pittsburgh 19, Pa.
Lubricating Oils, Greases, Gasoline and Diesel Fuels

Haiss, George, Mfg. Co., Inc., Division of Pettibone Mulliken Corp.
5720 Empire State Bldg., New York 1, N. Y.
Bucket Loaders, Buckets, Portable and Stationary Conveyors, Car Unloaders

Harnischfeger Corp.
4400 West National Ave., Milwaukee 14, Wis.
A complete line of Power Excavating Equipment, Overhead Cranes, Hoists, Smootharc Welders, Welding Rod, Motors and Generators, Diesel Engines

HarriSteel Products Co.
420 Lexington Ave., New York 17, N. Y.
Woven Wire Screen Cloth

Hayward Co.
50 Church St., New York 7, N. Y.
Orange Peel Buckets, Clam Shell Buckets, Electric Motor Buckets, Automatic Take-up Reels

Heidenreich, E. Lee, Jr.
Consulting Engineers
75 Second St., Newburgh, N. Y.
Plant Layout, Design, Supervision; Open Pit Quarry Surveys; Appraisals—Plant and Property

Hendrick Mfg. Co.
Carbondale, Pa.
Perforated Metal Screens, Perforated Plates for Vibrating, Shaking, and Revolving Screens; Elevator Buckets; Test Screens; Wedge Slot Screens; Open Steel Floor Grating

Hercules Powder Co.
Wilmington 99, Del.
Explosives and Blasting Supplies

Hetherington & Berner Inc.
701-745 Kentucky Ave., Indianapolis 7, Ind.
Asphalt Paving Machinery, Sand and Stone Dryers

Hewitt-Robins Incorporated
666 Glenbrook Road, Stamford, Conn.
Belt Conveyors (Belting and Machinery); Belt and Bucket Elevators; Car Shake-outs; Feeders; Industrial Hose; Screen Cloth; Sectional Conveyors; Skip Hoists; Stackers; Transmission Belting; Vibrating Conveyors, Feeders, and Screens; Design and Construction of Complete Plants

Hughes Tool Co.
P. O. Box 2539, Houston 1, Texas
Drills and Drilling Equipment

Illinois Powder Mfg. Co.
506 Olive St., St. Louis 1, Mo.
Gold Medal Explosives

Ilyus, Edmund Burwell
Consulting Engineer
15½ Franklin Road, S. W., Roanoke, Va.
Surveys, Appraisals, Reports and Design of Processing Plants; Storage Methods; Materials Handling

Ingersoll-Rand Co.
11 Broadway, New York 4, N. Y.
Rock Drills, Quarrymaster Drills, Jackbits, Bit Reconditioning Equipment, Portable and Stationary Air Compressors, Air Hoists, Slusher Hoists, Air Tools, Diesel Engines, Pumps

Insley Manufacturing Corp.
801 North Olney St., Indianapolis 6, Ind.
Concrete Carts and Buckets; 1/2 to 2 Cu. Yd. Cranes and Shovels—5 to 30 Tons Capacity

Iowa Manufacturing Co.
916 16th St., N.E., Cedar Rapids, Iowa
Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Hot and Cold Mix Asphalt Plants, Stabilizer Plants, Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills, Bins

Jaeger Machine Co.
550 West Spring St., Columbus 16, Ohio
Portable and Stationary Air Compressors, Self-Priming Pumps, Truck Mixers, Concrete Mixers, Road Paving Machinery, Hoists and Towers

Manufacturers Division—National Crushed Stone Association

(continued)

Jeffrey Manufacturing Co.
East First Ave., Columbus 16, Ohio
Material Handling Machinery, Crushers, Pulverizers, Screens, Chains

Johnson-March Corp.
1724 Chestnut St., Philadelphia 3, Pa.
Dust Allaying Equipment

Joy Manufacturing Co.
333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.
Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, and Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists; Multi-Purpose and Portable Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; "Spaders"; "String-a-Lite" (Safety-Lighting-Cable); Backfill Tampers; Drill Bits: Rock and Core

Kennedy-Van Saun Mfg. & Eng. Corp.
2 Park Ave., New York 16, N. Y.
Crushing, Screening, Washing, Conveying, Elevating, Grinding, Complete Cement Plants, Complete Lime Plants, Complete Lightweight Aggregate Plants, Synchronous Motors, Air Activated Containers for Transportation of Pulverized Material, Cement Pumps, and Power Plant Equipment

Kensington Steel Co.
505 Kensington Ave., Chicago 28, Ill.
Manganese Steel Castings, Dipper Teeth, Crawler Treads, Jaw Plates, Concaves and Hammers

King Powder Co., Inc.
Cincinnati, Ohio
Detonite, Dynamites, and Blasting Supplies

Koehring Co.
3026 West Concordia Ave., Milwaukee 16, Wis.
Excavating, Hauling and Concrete Equipment

Le Roi Co.
Cleveland Rock Drill Division
12500 Berea Road, Cleveland 11, Ohio
Air Compressors—Portable 60 Cfm. to 600 Cfm. Gas or Diesel; Tractairs—Combined Tractor with 105 Cfm. Air Compressor; Engines; Generator Sets; Rock and Wagon Drills; Jumbo Drill Rigs, Drifters, Stopers, Self Propelled Drill Rigs; Concrete Mixers, Front End Loaders

Linde Air Products Co., Division of Union Carbide and Carbon Corp.
30 East 42nd St., New York 17, N. Y.
Oxygen, Acetylene Welding Equipment and Supplies

Link-Belt Co.
300 West Pershing Road, Chicago 9, Ill.
Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, Speed-O-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Ludlow-Saylor Wire Cloth Co.
634 South Newstead Ave., St. Louis 10, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, All Commercial Alloys and Metals

Mack Motor Truck Corp.
350 Fifth Ave., New York 1, N. Y.
On- and Off-Highway Trucks, Tractor Trailers, Six-Wheelers, from 5 to 30 Tons Capacity, both Gasoline- and Diesel-Powered

Marion Power Shovel Co.
617 West Center St., Marion, Ohio
A Complete Line of Power Shovels, Draglines, and Cranes

McLanahan & Stone Corp.
200 Wall St., Hollidaysburg, Pa.
Complete Pit, Mine, and Quarry Equipment—Crushers, Washers, Screens, Feeders, Etc.

Murphy Diesel Co.
5317 West Burnham St., Milwaukee 14, Wis.
Engines and Power Units—90 to 246 Hp.; Generator Sets—60 to 154 Kw.; Marine Engines—90 to 225 Hp.; Dual-Fuel Engines—135 to 180 Hp.; Mechanical and Electric Power Simultaneously

National Container Corp. of Ohio
Multi-Wall Paper Bag Division
Jaite, Ohio
Multiwall Paper Bags, Sewn and Pasted Style for Packaging Lime, Cement, Plaster, Etc.

New York Rubber Corp.
100 Park Ave., New York 17, N. Y.
Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor

Nordberg Mfg. Co.
3073 South Chase Ave., Milwaukee 7, Wis.
Symons Cone and Gyratory Crushers; Gyradisc; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens and Grizzlies; Diesel Engines and Diesel Driven Generator and Pumping Units; Mine Hoists; Track Maintenance Machinery

Manufacturers Division—National Crushed Stone Association

(continued)

Northern Blower Co.
6409 Barberton Ave., Cleveland 2, Ohio
Dust Collecting Systems, Fans—Exhaust and Blower

Northwest Engineering Co.
135 South LaSalle St., Chicago 3, Ill.
Shovels, Cranes, Draglines, Pullshovels

Olin Industries, Inc.
Explosives Division
East Alton, Ill.
Dynamite, Black Powder, Blasting Caps, Blasting Supplies

Osgood Co.
Osgood St. and Cheney Ave., Marion, Ohio
Power Shovels, Cranes, Draglines, Hoes, Etc., 3/8 to 2 1/2 Cu. Yd.

Pennsylvania Crusher Co.
Liberty Trust Bldg., Broad and Arch Sts., Philadelphia 7, Pa.
Single Roll Crushers, Impactors, Hammermills, Ring Type Granulators, Kue-Ken Jaw Crushers, Kue-Ken Gyracones, Dixie Non-Clog and Standard Hammermills

Pettibone Mulliken Corp.
4710 West Division St., Chicago 51, Ill.
Material Handling Buckets, Clamshells, Draglines, Pullshovels, Dippers, Shovel Dippers, Pumps, Hammermills, Front End Loaders, Bucket Conveyor Loaders, Fork and Bucket Loaders, Motor Graders, Manganese Steel Castings

Pioneer Engineering Works, Inc.
1515 Central Ave., N. E., Minneapolis 13, Minn.
Jaw Crushers, Roll Crushers (Twin and Triple), Vibrating and Revolving Screens, Feeders (Mechanical, Grizzly, Apron, and Pioneer-Oro), Belt Conveyors, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants

Pit and Quarry Publications, Inc.
431 South Dearborn St., Chicago 5, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Productive Equipment Corp.
2926 West Lake St., Chicago 12, Ill.
Vibrating Screens

Quaker Rubber Corp.
Tacony and Milnor Sts., Philadelphia 24, Pa.
Conveyor Belts, Hose, and Packings

Radio Corporation of America
Engineering Products Department
Industrial Equipment Section
Front and Cooper Sts., Bldg. 15-1, Camden 2, N. J.
Electronic Metal Detectors

Rock Products
309 West Jackson Blvd., Chicago 6, Ill.

Rogers Iron Works Co.
11th and Pearl Sts., Joplin, Mo.
Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos and Underground Loaders

Screen Equipment Co., Inc.
1754 Walden Ave., Buffalo 25, N. Y.
Seco Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screens, Horizontal Screens, Simpli-Flo Screens, Tray Type Screens, Heavy Duty Scalpers, D'Watering Wheels, D'Centegrators, Vibrating Feeders, Vibrating Pan Conveyors

SKF Industries, Inc.
Front St. and Erie Ave., P. O. Box 6731, Philadelphia 32, Pa.
Anti-Friction Bearings—Self-Aligning Ball, Single Row Deep Groove Ball, Angular Contact Ball, Double Row Deep Groove Ball, Spherical Roller, Cylindrical Roller, Ball Thrust, Spherical Roller Thrust; Pillow Block and Flanged Housings—Ball and Roller

Smith Engineering Works
532 East Capitol Drive, Milwaukee 12, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Manufacturers Division—National Crushed Stone Association
(concluded)

Stedman Foundry & Machine Co., Inc.
Aurora, Ind.
Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers, Multi-Cage Limestone Pulverizers, Vibrating Screens

Stephens-Adamson Mfg. Co.
Aurora, Ill.
Belt Conveyors, Elevators, Feeders, Car Pullers, Screens, Skip Hoists, Complete Plants

Talcott, W. O. & M. W., Inc.
91 Sabin St., Providence 1, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate

Thew Shovel Co.
East 28th St. and Fulton Rd., Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines, Diesel Electric, Gasoline, 3/8 to 2 1/2 Cu. Yd. Capacities

Torrington Co.
Bantam Bearings Division
3702 West Sample St., South Bend 21, Ind.
Anti-Friction Bearings; Self-Aligning Spherical, Tapered, Cylindrical, and Needle Roller; Roller Thrust; Ball Bearings

Travel Drill Co.
P. O. Box 1124, Raleigh, N. C.
"Travel Drill"—Mobile Drill for Secondary Drilling in Quarries and Open Pit Work

Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime, and Cement Machinery

Trojan Powder Co.
17 North 7th St., Allentown, Pa.
Explosives and Blasting Supplies

Tyler, W. S., Co.
3615 Superior Ave., N. E., Cleveland 14, Ohio
Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers; Tyler Standard Screen Scale Sieves, U. S. Sieve Series

Unit Crane & Shovel Corp.
6411 West Burnham St., Milwaukee 14, Wis.
1/2 and 3/4 Cu. Yd. Crawler, Rubber Mounted Shovels, Clamshells, Draglines

Universal Engineering Corp.
625 C Ave., N. W., Cedar Rapids, Iowa.
Jaw Crushers, Roll Crushers, Hammermills, Complete Crushing, Screening, and Loading Plants, Either Stationary or Portable for Stone Aggregates or Aglime, Portable and Stationary Washing Plants, Asphalt Plants, and Impact Breakers

Vibration Measurement Engineers
7665 Sheridan Road, Chicago 26, Ill.
Seismographic and Airblast Measurements, Seismological Engineering, Blasting Complaint Investigations, Expert Testimony in Blasting Litigation; Nation-wide Coverage

Werco Steel Co.
2151 East 83rd St., Chicago 17, Ill.
Crusher Jaws, Roll Shells, Mantles, Bowl Liners, Conveyor and Elevator Chain, All Types Wear Resistant Steel Manganese and Alloy Steel Castings, Screen Plate—Perforated Steel, Screen Sections and Decks

Weston Dump Body Co.
326 S.W. 11th St., Des Moines 9, Iowa
Combination Lime, Sand, and Gravel Body; Special Bodies for Quarry and Pit Work

Wheeler, Delbert
2408 Harrison St., Topeka, Kans.
Wheeler Testing Vibrators

White Motor Co.
842 East 79th St., Cleveland 1, Ohio
On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines, Power Units, Axles, Special Machine Assemblies; All Classes of Service

Technical Publications
of the
National Crushed Stone Association

STONE BRIEFS

No. 1. How to Proportion Workable Concrete for Any Desired Compressive Strength

No. 2. How to Proportion Concrete for Pavements

No. 3. Uses for Stone Screenings

No. 4. How to Determine the Required Thickness of the Non-Rigid Type of Pavement for Highways and Airport Runways

No. 5. The Insulation Base Course Under Portland Cement Concrete Pavements

ENGINEERING BULLETINS

No. 1. The Bulking of Sand and Its Effect on Concrete

No. 2. Low Cost Improvement of Earth Roads with Crushed Stone

No. 3. The Water-Ratio Specification for Concrete and Its Limitations (Supply Exhausted)

No. 4. "Retreading" Our Highways

No. 5. Reprint of "Comparative Tests of Crushed Stone and Gravel Concrete in New Jersey" with Discussion

No. 6. The Bituminous Macadam Pavement

No. 7. Investigations in the Proportioning of Concrete for Highways

No. 8. The Effect of Transportation Methods and Costs on the Crushed Stone, Sand and Gravel, and Slag Industries (Supply Exhausted)

No. 9. Tests for the Traffic Durability of Bituminous Pavements

No. 10. Stone Sand (Supply Exhausted)

No. 11. A Method of Proportioning Concrete for Strength, Workability, and Durability. (Revised November 1953)

•

Single copies of the above publications are available upon request.

•

Manual of Uniform Cost Accounting Principles and Procedure for the Crushed Stone Industry (*$2.00 per copy*)